1.0 INTRODUCTION

The coastal zone is a unique geological, physical, and biological area of vital economic and environmental value. Houston (1995) particularly discusses the value of beaches and their maintenance via beach nourishment to America's economy. Not only are beaches the dominant component of most coastal economies, but they also provide a measured level of protection against high winds and waves associated with storms. Miller (1993) stresses the importance of coastal and marine tourism as the world's largest industry and its continual rise over the past 50 years. As such, beaches are key elements of coastal tourism because they represent the leading tourist destination.

Coastal community master plans are being developed and revised to address concerns associated with population growth, storm protection, recreation, waste disposal and facilities management, and zoning (Williams, 1992). Often, problems stemming from these issues are in direct conflict with natural coastal processes. Some of the more direct problems are related to coastal erosion and storm protection. The practice of replenishing beaches with sand from upland and nearshore sources as protection for community infrastructure has increased in direct relation to population growth. As coastal and nearshore borrow areas become depleted, and our knowledge of environmental effects of coastal sand mining develop, alternate sources of aggregate and beach fill must be evaluated for offshore sites to meet specific societal needs. In many cases, sand resource extraction from the Outer Continental Shelf (OCS) may prove environmentally preferable to nearshore borrow areas due to potential changes in waves and currents as large quantities of sand are dredged from the seafloor.

Denmark, Japan, The Netherlands, and United Kingdom have been actively involved in marine mining of sand and gravel for the past few decades. The U.S. recognizes the potential benefits of sand and gravel mining on the Outer Continental Shelf (OCS), as well as the potential for environmental impacts. The U.S. Department of Interior (USDOI), Minerals Management Service (MMS) is responsible for managing the exploration and development of sand and gravel resources on the OCS seaward of State boundaries. In 1983, the MMS established the Office of Strategic and International Minerals for evaluating the prospects for and conditions under which sand and gravel mining would develop in the U.S. In 1991, the Office of International Activities and Marine Minerals (INTERMAR) was created to develop strategies for addressing specific concerns regarding offshore sand and gravel mining operations (Hammer et al., 1993).

The MMS has significant responsibilities with respect to the potential environmental impacts of sand and gravel mining. Existing regulations governing sand and gravel mining provide a framework for comprehensive environmental protection during operations. Specific requirements exist for evaluations and lease stipulations that include appropriate mitigation measures (Hammer et al., 1993). Guidelines for protecting the environment stem from a wide variety of laws, including the OCS Lands Act (OCSLA), National Environmental Policy Act (NEPA), Endangered Species Act, Marine Mammals Protection Act, and others. Regulations require activities to be conducted in a manner which prevents or minimizes the likelihood of any occurrences that may cause damage to the environment. The MMS takes a case-by-case approach in conducting environmental analyses, as required by NEPA and the Council on Environmental Quality (CEQ) regulations.

In recent years, there has been increasing interest in sand and gravel mining on the OCS. Currently, eight State-Federal task forces, several cooperative agreements, at least five negotiated agreements, and four environmental surveys exist to ensure substantive government and public involvement and attention to regional, State, and local concerns regarding leasing, engineering, economic, and environmental aspects of sand and gravel mining. Under the OCSLA, the MMS is required to conduct environmental studies to obtain information useful for decisions related to negotiated agreements and lease activities. As such, the MMS pursues its responsibilities for management of offshore sand and gravel mining vigorously by:

- protecting ocean and coastal environments by ensuring that all OCS sand and gravel mining activities are environmentally acceptable;
- ensuring the OCS sand and gravel activities are compatible with other uses of the ocean;
- involving coastal States in all aspects of sand and gravel mining activities; and
- evaluating the potential of the OCS as a domestic source for sand and gravel resources.

To this end, the MMS initiated four environmental studies along the Atlantic and Gulf coasts in FY97 to provide information for programmatic marine mining decisions at MMS Headquarters and OCS Regional Offices. This report presents the results of the first of four environmental studies administered through INTERMAR. Entitled "Environmental Study of Identified Sand Resource Areas Offshore Alabama", this program was initiated by Aubrey Consulting, Inc. (ACI) in April 1997 under MMS Contract No. 14-35-01-97-CT-30840. This report was prepared by Applied Coastal Research and Engineering, Inc. (Applied Coastal) in cooperation with Continental Shelf Associates, Inc. (CSA), ACI, and Barry A. Vittor & Associates, Inc. (BVA).

1.1 STUDY AREA

The inshore portion of the continental shelf, seaward of the State-Federal OCS boundary and within the Alabama Exclusive Economic Zone (EEZ), encompasses the project study area (Figure 1-1). The seaward limit of the study area is defined by the 30°05'N latitude line. The project area is located within the east Louisiana-Mississippi-Alabama Shelf (ELMAS). The continental shelf surface within the study area is relatively broad and featureless west of the Mobile Bay entrance; however, the Alabama shelf east of the entrance channel contains many northwest-southeast trending shoreface sand ridges, as well as other shoals (Figure 1-1).

Five potential sand resource areas were defined within the study area through a Federal-State cooperative agreement between MMS-INTERMAR and the Geological Survey of Alabama (GSA). Table 1-1 provides a list of coordinates defining the extent of each resource area. Parker et al. (1993, 1997) characterize the sand resource potential for each borrow area (defined by Parker [1990]) based on surface sediment samples and vibracore data. Hummell and Smith (1995, 1996) provide detailed geologic information on Sand Resource Area 4 to supplement existing information, identifying a specific low-relief shoal in the southeast quadrant of the sand resource area as the prime borrow area. Specific parts of Sand Resource Areas 1, 2, and 3 currently are being analyzed by the GSA using new vibracore and surface sediment samples to determine the quantity of sand available for future beach fills. The GSA report to MMS-INTERMAR is due in 1999. For the present study, four borrow sites within Sand Resource Areas 1 through 4 were defined to evaluate potential impacts of sand mining for beach replenishment (see Section 7.0). Sand Resource Area 5 was not included in the analysis because it is away from beach areas of greatest replenishment need, and the sediment was least compatible with native beach sand (see Parker et al., 1997).

Table 1-1. UTM Coordinates defining resource areas offshore Alabama (see Figure 1-1).

Resource Area	UTM –x and –y coordinate pairs (easting, northing; Zone 16, NAD83)			
	Northwest	Northeast	Southeast	Southwest
1	433599.8, 3343440.7	439695.6, 3343497.7	439966.0, 3334262.3	433625.3, 3334390.6
2	424999.2, 3340725.8	432462.1, 3341046.5	432392.2, 3329688.6	425085.2, 3329834.3
3	408795.2, 3341033.2	418425.2, 3341418.9	418738.4, 3332150.8	409042.5, 3332165.5
4	387958.5, 3341778.8	397087.6, 3341691.0	397219.5, 3330053.1	388387.4, 3330323.6
5	367217.6, 3339795.0	373396.3, 3339722.0	373561.7, 3333162.2	367220.8, 3333422.7

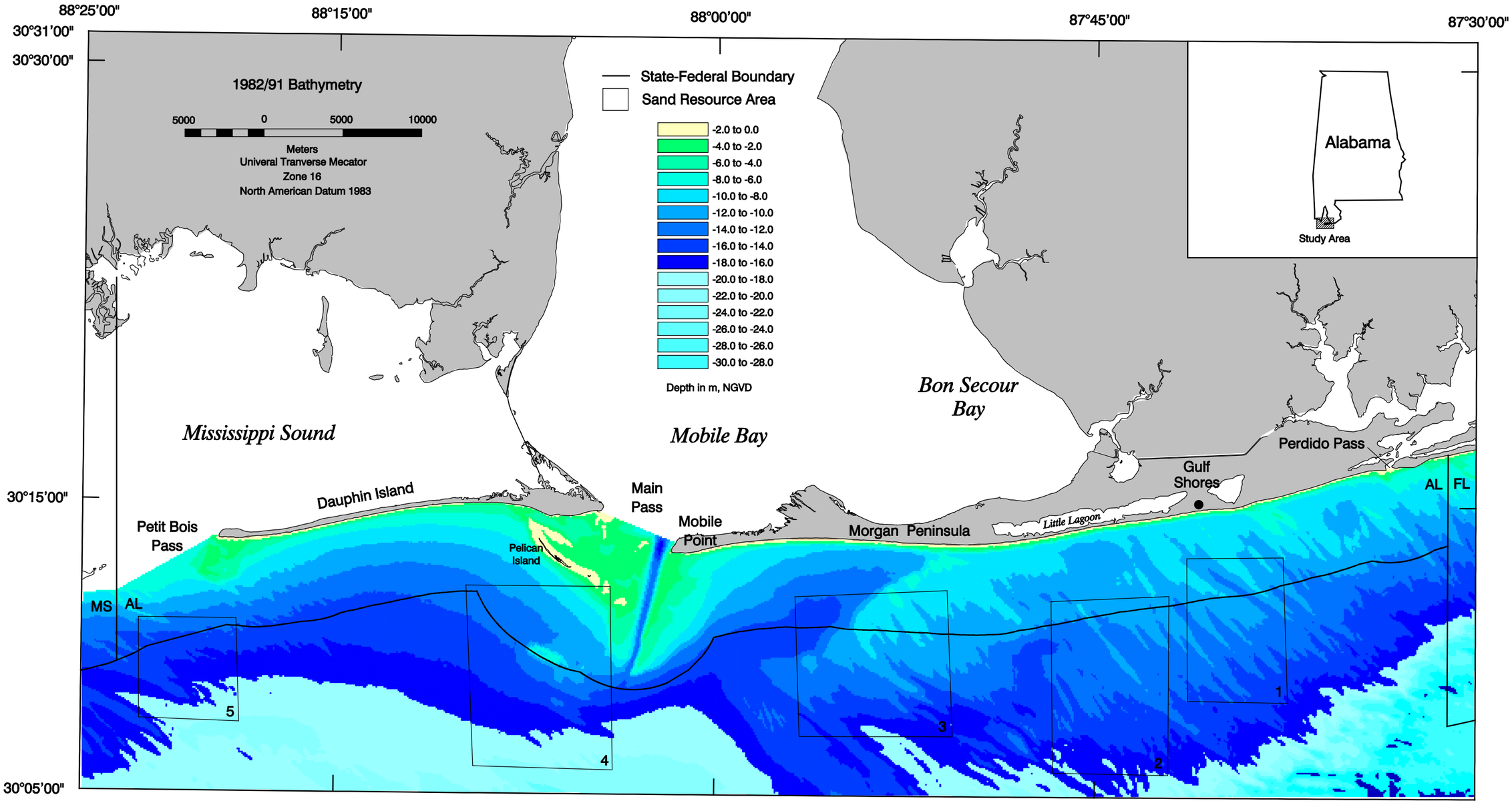

Figure 1-1. Location diagram illustrating sand resource areas and State-Federal boundary relative to 1982/91 bathymetry

1.2 STUDY PURPOSE

The primary purpose of this study was to address environmental concerns raised by the potential for dredging sand from the OCS offshore the State of Alabama for beach replenishment and to document the findings in a technical report. The primary environmental concerns focused on biological and physical components of the environment. To this end, seven study objectives were identified:

- Compile and analyze existing oceanographic literature and data sets to develop an understanding of existing environmental conditions offshore Alabama and the ramifications of dredging operations at selected sand borrow sites;
- Design and conduct biological and physical field data collection efforts to supplement existing resources;
- Analyze the physical and biological field data sets to address basic environmental concerns regarding potential sand dredging operations;
- Use physical processes field data sets and wave climate simulations to predict wave transformation under natural conditions and in the presence of proposed dredging activities;
- Determine existing coastal and nearshore sediment transport patterns using historical data sets, and predict future changes resulting from proposed sand dredging operations;
- Evaluate the potential cumulative environmental effects of multiple dredging scenarios; and
- Develop a document summarizing the information generated to assist with decisions concerning preparation of an Environmental Assessment/Impact Statement to support a negotiated agreement.

In meeting these objectives, this document should provide invaluable information regarding environmental concerns examined relative to proposed future sand dredging in support of beach replenishment needs from offshore Alabama.

1.3 STUDY APPROACH

Biological and physical processes data were collected and analyzed to assess the potential impacts of offshore dredging activities within the study area to minimize or preclude long-term adverse environmental impacts at potential borrow sites and along the coastline landward of resource sites. In addition, wave transformation and sediment transport numerical modeling were employed to simulate the physical environmental effects of proposed sand dredging operations to ensure that offshore sand resources are developed in an environmentally sound manner.

Five primary study elements were outlined in Task 1 (Data Collection and Analysis) of the Request for Proposals for addressing environmental concerns associated with offshore sand dredging for beach replenishment. They included:

- Assessment of baseline benthic ecological conditions, using existing data sets and data collected from field work, in and around the five proposed sand borrow areas;
- Evaluation of the benthic infauna present in the five proposed borrow areas, and assessment of the potential effects of offshore sand dredging on these organisms, including an analysis of the potential rate and success of recolonization following dredging;
- Development of a schedule of best and worst times for offshore sand dredging in relation to transitory pelagic species;

- Evaluation as to the potential modification to waves that propagate within the study area due to offshore sand dredging within the proposed sand borrow areas; and
- Evaluation of the impact of offshore dredging and consequent beach replenishment in terms of potential alteration to sediment transport patterns, sedimentary environments, and impacts to local shoreline processes.

The first three study elements focused primarily on biology and associated ecological impacts relative to potential sand dredging operations. The final two elements concentrated on potential alterations to physical processes and sedimentary environments, as well as potential shoreline response to incident waves and currents resulting from dredging operations. The scientific approach used to address each of the study elements is presented below. The remaining study tasks (2-14) focused on document preparation and project management requirements. Figure 1-2 shows the organization of the project team and individual responsibilities.

1.3.1 Baseline Ecological Conditions

The goal of this study element was to assess baseline ecological conditions (biology, water column parameters, physical processes, sedimentologic characteristics) in and around the five sand resource areas. This phase of the study primarily focused on field data collection efforts conducted in May, September, and December 1997 (presented in detail in Sections 5.0 and 6.0). However, existing literature and data were compiled and summarized to characterize the ecological environment and to form the foundation upon which field surveys were designed. Biological field surveys were conducted in May and December 1997 to characterize infauna, epifauna, demersal ichthyofauna, sediment grain size, and water column parameters (detailed in Section 6.0). Because Mobile Bay entrance flows potentially have significant impact on the physical processes (waves, currents, and sediment transport dynamics) affecting ecological conditions in the sand resource areas, total currents were measured at resource areas west and east of the entrance using an Acoustic Doppler Current Profiler (ADCP). Existing data sets were analyzed to document temporal variations in flow throughout the study area, whereas ADCP measurements were used to examine spatial variations throughout the water column (detailed in Section 5.0).

1.3.2 Benthic Infaunal Evaluation

The goal of this study element was to assess the potential effects of offshore dredging on benthic infauna and analyze the potential rate and success of recolonization following cessation of dredging activities. Existing literature and data on dredging effects were searched and synthesized then combined with results from the biological field surveys to examine potential benthic effects and recolonization in the sand resource areas.

1.3.3 Project Scheduling

The goal of this study element was to determine the best and worst times for offshore dredging relative to pelagic species. Environmental windows are temporal constraints placed on dredging activities to protect biological resources from potentially detrimental effects (Dickerson et al., 1998). Existing information was collected and summarized concerning the seasonal occurrence of pelagic species in the five sand resource areas and potential impacts from dredging. Project scheduling considerations for pelagic species then were analyzed based on this information.

1.3.4 Wave Modifications

The goal of this study element was to perform wave transformation numerical modeling to predict the potential for adverse modification of waves resulting from sand dredging operations. Changes in bathymetry in sand resource areas can cause wave energy focusing resulting in

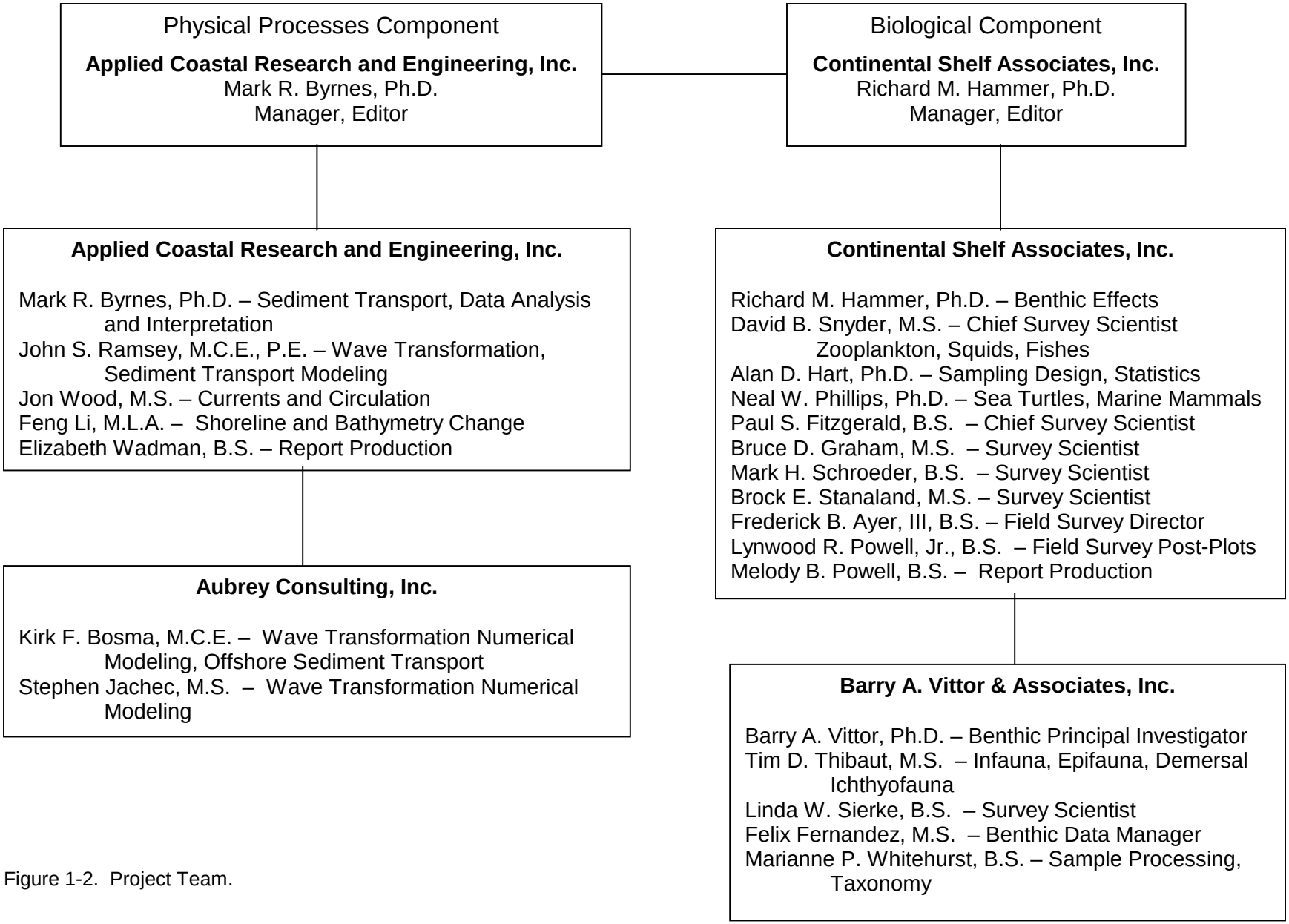

Figure 1-2. Project Team.

substantial alterations in sediment transport at the site of dredging operations, as well as along the shoreline landward of the borrow site. Because the purpose of dredging offshore sand from a specific site will be driven by the need for beach replenishment, it is critical to understand the impact of changing wave transformation patterns on shoreline response before potentially exacerbating a problem. Numerical comparisons of pre-and post-dredging impacts provided a means of documenting modifications to waves as they crossed the five sand resource areas.

1.3.5 Sediment Transport Patterns

The goal of this study element was to predict changes in sediment transport patterns resulting from potential sand dredging operations using numerical information generated from wave transformation modeling, combined with offshore current data (ADCP). Sediment transport rates were quantified for sand resource sites using an analytical approach, whereas transport rates at the shoreline were determined numerically using output from wave transformation numerical modeling (detailed in Section 5.0).

Historical shoreline and bathymetry data were compiled to document regional sediment transport patterns over a 60-yr time period. Net changes in sediment erosion and deposition on the shelf surface offshore Alabama provided a direct method for identifying patterns of sediment transport and quantifying net rates of change throughout the potential sand resource areas (detailed in Section 3.0). These data also were used to calibrate numerical results for direction and magnitude of transport.

1.4 DOCUMENT ORGANIZATION

Information presented in this document represents the culmination of a year and a half of work among experts in the fields of biology and benthic ecology (CSA and BVA) and coastal processes (Applied Coastal and ACI), under the direction of Mr. Barry Drucker (MMS INTERMAR). This document was organized into nine major sections as follows:

- Introduction
- Environmental Setting
- Regional Geomorphic Change
- Wave Transformation Numerical Modeling
- Circulation and Sediment Transport Dynamics
- Biological Field Surveys
- Potential Effects
- Conclusions
- Literature Cited

The sections are presented in a different order than the list of study elements in the RFP. Because benthic and pelagic biological characteristics are in part determined by spatially varying physical processes throughout the study area, physical processes analyses are summarized first.

In addition to the main document, appendices were prepared in support of many of the analyses presented in each section of the report. Furthermore, an Executive Summary, a Technical Summary, and a Non-Technical Summary were prepared as separate documents to provide a brief description of study methods and findings for audiences ranging from researchers to non-technical people.